Scattering of fast neutrons by neon-20 and neon-22.

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SUMMARY

The subject of this thesis is an investigation of the scattering of fast monoenergetic neutrons by the nuclei ^{20}Ne and ^{22}Ne, in the neutron energy range 1.9 to 3.5 MeV. The method is wholly based on the ionization produced in gaseous neon by the neon recoil nuclei arising from collisions with neutrons. To measure the individual ionizations, the neon is contained in a proportional counter. The voltage pulse from such a counter is proportional in height to the number of ions liberated, which in turn is approximately proportional to the energy of the ionizing particle. Since the energy of a recoil nucleus depends on the scattering angle of the neutron, pulse-height distributions provide information on the angular distribution of the scattering process.

To measure the total cross section, pulses from the counter should be recorded with low discriminator threshold. In this case, however, one experiences serious background problems, mainly due to pulses from Compton- or photoelectrons liberated by γ-rays. We largely reduced this background by using a multiple-wire counter, in conjunction with an anticoincidence system (section 2.5). Thus it was possible to measure the total cross section with reasonable accuracy. This new method is especially useful for separated gaseous isotopes, as the amount required is much smaller than in case of transmission experiments.

To determine absolute values of total and differential cross sections, neutron flux measurements were performed with a high-pressure hydrogen recoil counter, filled with methane and argon (sections 2.6 and 4.2).

Because of the important role of proportional counters in the present measurements, general properties of these counters and the construction of our counters have been discussed separately in chapter II. New methods have been described for eliminating end-effects in counters (section 2.3) and for investigating electron attachment in high-pressure counters (section 2.6.2).

Chapter III deals with the measuring arrangement and properties of the D+D neutron source (heavy ice bombarded with deuterons). The error in the energy of the neutrons and the neutron energy spread are also discussed.

A full discussion of our method of measuring and possible experimental errors has been given in chapter IV. A brief des-

cription of the electronic equipment has been given in the Appendix (p. 105).

Chapter V contains a review of the quantum-mechanical description of fast neutron scattering in the resonance region, in so far as this is applied to our results.

The experimental results obtained for ^{20}Ne and ^{22}Ne have been described in chapters VI and VII respectively. Measurements of the total cross section as a function of neutron energy in the region 1.9 to 3.5 MeV are illustrated by figure 29 for ^{20}Ne and by figure 38 for ^{22}Ne. The curves reveal the presence of many resonances in the scattering process for both nuclei (Cf. the tables given below).

For nuclear theory it is important to determine the resonance parameters for each resonance, namely the resonance energy E_r, the width Γ, the orbital angular momentum of the neutron l and the total angular momentum J. This is because these parameters are related to the properties of the excited states of the compound nucleus formed by neutron capture. Apart from the total cross section curve, information about resonance parameters may be obtained from differential elastic scattering cross sections at resonances and between resonances (chapter V). For this purpose pulse-height distributions were measured at various neutron energies. The results are shown in figures 31, 35 and 36 for ^{20}Ne and figures 40 and 41 for ^{22}Ne.

In our case, the determination of resonance parameters is rendered more difficult by the presence of inelastic scattering in addition to elastic scattering. This complicates the phenomena at resonances, and restricts the information about elastic scattering obtained from pulse-height distributions, due to the occurrence of pulses from inelastic recoils.

An additional difficulty is the frequent overlapping of resonances in our neutron energy region. A complete determination of resonance parameters was therefore possible only for the resonances with ^{20}Ne at 1.94 and 2.00 MeV neutron energy. In these cases the energy of the neutrons after inelastic scattering is comparatively low, resulting in a small contribution of this process. We found the resonance at 1.94 MeV to be caused by neutrons with $l = 2$ and $J = {}^3/_2$ ($D_{3/2}$ neutrons), whereas the resonance at 2.00 MeV turned out to be due to neutrons with $l = 1$ and $J = {}^3/_2$ ($P_{3/2}$ neutrons) (Cf. section 6.5.1 and Table 6.3).

The strong resonance peaks in the total cross section of ^{20}Ne at

2.11 MeV and ^{22}Ne at 2.32 MeV are both probably caused by a superposition of a $P_{3/2}$ and a $D_{3/2}$ resonance (sections 6.5.2 and 7.5.1).

The resonance parameters following from our measurements are summarized in the tables below.

Resonances with ^{20}Ne

E_r (MeV)	1.94	2.00	2.11	2.45	2.57	2.73	2.88	3.28
Γ (keV)	32	48						
l, J	$D_{3/2}$	$P_{3/2}$	$(P_{3/2}, D_{3/2})$					

Resonances with ^{22}Ne

E_r (MeV)	2.11	2.14	2.19	2.32	2.53	2.72	2.87	3.10	3.20	3.43
Γ (keV)				160	25	90				
l, J				$P_{3/2}, D_{3/2}$						